Question #75494

Description:

a) What is transport phenomenon? Obtain an expression for:
i) the average number of molecules crossing an arbitrary plane from either side per unit area per second is N ,v
ii) the average height at which a molecule makes its last collision before crossing the plane is .
3
2
λ
iii) Using the results in (i) and (ii) obtain an expression for viscosity of the gas.
iv) Discuss its pressure and temperature dependence.

Solution.

1.basic equation of molecular kinetic theory

$$p = nkT$$

where n concentration, p pressure,T temperature,
the required number of molecules is (taking into account the probable movement of 3 axes)

$$N = \frac{n\langle v^2\rangle S}{6}$$

Where $\langle v^2\rangle$ the mean quadratic velocity, S the area of the plane and equal condition 1 m^2, taking into account the motion in both directions through the plane

$$N = \frac{n\langle v^2\rangle S}{6}2 = \frac{n\langle v^2\rangle 1}{3} = \frac{n}{3}\sqrt{\frac{3RT}{M}}$$

Where T temperature, R universal gas constant, M molar mass.

2. According to Maxwell's distribution, the free run will be

$$\lambda = \frac{1}{\sqrt{2}\pi d^2 n}$$

d the effective radius of the molecule if λ= 2 or 3 m

$$d = \sqrt{\frac{1}{\sqrt{2}\pi 2n}}, \sqrt{\frac{1}{\sqrt{2}\pi 2n}}$$

3 Gas viscosity

$$\eta = \frac{1}{3}\rho\langle v^2\rangle\lambda$$

taking into account the formula of the Mendeleev - Clapeyron, the length of the free path of molecules and required number N, and basic equation of molecular kinetic theory

$$\eta = \frac{1}{3}\frac{pM}{RT}\sqrt{\frac{3RT}{M}}\frac{1}{\sqrt{2}\pi d^2 n} = \frac{1}{3}\frac{pM}{RT}\sqrt{\frac{3RT}{M}}\frac{kT}{\sqrt{2}\pi d^2 p} = \sqrt{\frac{TM}{3R}}\frac{k}{\sqrt{2}\pi d^2}$$

4 Gas viscosity viscosity is virtually independent of pressure for gases subject to Maxwell statistics that is, it means

$$\frac{\partial\eta}{\partial p} = 0$$